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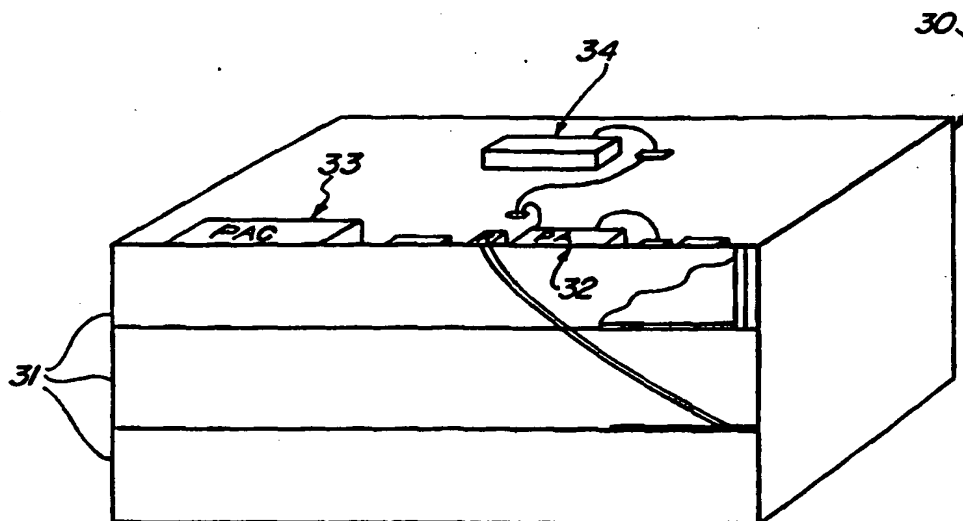
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(21) International Application Number: PCT/US98/20574 (22) International Filing Date: 30 September 1998 (30.09.98) (30) Priority Data: 08/941,488 30 September 1997 (30.09.97) US (71) Applicant: ROCKWELL SEMICONDUCTOR SYSTEMS, INC. [US/US]; 4311 Jamboree Road, Newport Beach, CA 92660-3095 (US). (72) Inventor: VAKILIAN, Nooshin; 7 Trapani, Irvine, CA 92614 (US). (74) Agent: ANDRAS, Joseph, C.; Suite 650, 650 Town Center Drive, Costa Mesa, CA 92626 (US).		(81) Designated States: JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i>

(54) Title: MULTI-LAYER CARRIER MODULE FOR POWER AMPLIFIER



(57) Abstract

A single multi-layer carrier module (30) is disclosed which carries the power amplifier (32) components in a GSM mobile digital cellular telephone. In a first embodiment of the present invention the power amplifier (32) and the power amplifier controller (33) are placed upon a ceramic or laminate carrier module (31) along with necessary connection circuitry. The carrier module (30) is then connected to the RF board. In a second preferred embodiment of the present invention the power amplifier (32), the power amplifier controller (33) and a voltage controlled oscillator (34) are placed upon the carrier module (30).

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1

1 **MULTI-LAYER CARRIER MODULE FOR POWER AMPLIFIER**

2

3

4

5 FIELD OF THE INVENTION

6

7 The present invention relates generally to digital

8 wireless communication systems, and more particularly,

9 to a power amplifier system which incorporates multiple

10 power amplifier components upon a single carrier module

11 attached to the RF circuit board.

12

13

14 BACKGROUND OF THE INVENTION

15

16 Cellular telephone systems include a central base

17 station and multiple hand held mobile cellular phones.

18 The first generation of mobile cellular phones were

19 analog based systems. They were bulky, large, and

20 heavy. Further, the analog cellular phones had limited

21 channel capacity, in that there was one allowed

22 transmission per channel, causing excessive interference

23 between users and other limitations of use.

24

25 The next generation of cellular phones used digital

26 technology. Digital technology has allowed certain

27 digital signal processing systems and modulation or

28 transmission techniques within the cellular environment

29 which enable a larger channel capacity for

30 communications along with reduced interference and lower

31 error rates within the transmissions.

32 The speed with which the public accepts the

33 transition between generations of cellular phones,

34 including the transition from the first generation

35 analog mobile phones to the next generation digital

36 phones, is dependent upon certain factors including the

1 cost of the phones, the ease with which they may be
2 used, the transmission quality, and other features which
3 are desired by consumers.

4

5 While the first generation analog mobile cellular
6 phones were relatively the size of small books and
7 difficult to carry, the next generation of digital
8 cellular phones are comfortably pocket sized. Further,
9 there is a continuing desire to reduce the size and cost
10 of mobile cellular phone systems while still enabling
11 more functionality and electronics systems within the
12 hand-held cellular phone unit.

13

14 The standards currently used for digital cellular
15 telephony are different throughout world. The most
16 important current digital cellular telephone standards
17 are IS-54B which is used in the United States, Global
18 System for Mobile Communication (GSM) in Europe, and
19 RCR-27 in Japan. Each of these standards include
20 digital voice and data transmission capabilities.

21

22 Various bodies worldwide are currently developing
23 new standards for the specification of even the next
24 generation of mobile cellular telecommunications systems
25 along with their increased functionality. Services
26 offered by current wireless mobile systems are simply
27 telephony and voice services supported by narrowband
28 digital networks. However, there will be a demand for
29 higher bandwidth services as more comprehensive data and
30 information transmission services are provided within
31 the digital cellular network. Thus, today's wireless
32 interface must carry narrowband services effectively
33 while providing the flexibility to carry higher
34 bandwidth services as the demand increases.

35

1

2 Within the power amplifier control loop, an RF
3 coupler may be used at the power amplifier output in
4 order to couple the RF output from the power amplifier
5 to the RF logarithmic detector input. A common
6 directional coupler known in the art is available from
7 Murata Manufacturing Co., Ltd., Japan as part number
8 LDC20B200H0902.

9

10 As shown within figure 2, the input to the
11 logarithmic detector upon the RF122 power amplifier
12 controller should be within the range of -40 dBm to 10
13 dBm. The coupled signal is fed to the input of the RF
14 power detector on the RF122. The output from the
15 detector is a D.C. voltage that is proportional to the
16 RF power at the RF power amplifier output.

17

18 The integrating error amplifier amplifies and
19 integrates the voltage difference between the detector
20 output and the power control input. The output of the
21 integrator is fed to the gain shaping circuit which
22 drives the gain control input of the external RF power
23 amplifier. The integrator in the integrating error
24 amplifier is used to stabilize the loop. The D.C. bias
25 circuitry provides voltage bias to the RF122.

26

27 A common Voltage Controlled Oscillator may also be
28 provided on the RF board as an input drive to the power
29 amplifier. The Voltage Controlled Oscillator fits
30 within a phase locked loop at the power amplifier input,
31 which translates the complex spectrum up to the desired
32 channel within the transmit band. A common Voltage
33 Controlled Oscillator used in this application is
34 available from Murata Manufacturing Co., Ltd., Japan as
35 part number MQE550-902.

1
2 Each of the major components in the radio
3 subsystem, the power amplifier, the power amplifier
4 controller, and the voltage controlled oscillator are
5 separate components installed on the RF board which
6 requires space, connection circuitry and cost.

7
8
9 OBJECTS OF THE INVENTION

10
11 It therefore is an object of the present invention
12 to provide an improved digital cellular mobile phone
13 which is less expensive, smaller and easier to
14 manufacture.

15
16 It is a further object of the present invention to
17 provide an improved digital cellular mobile phone which
18 has an RF circuit board which is more compact and easier
19 to assemble.

20
21 It is yet a further object of the present invention
22 to provide an improved digital cellular mobile phone
23 which has less separate components upon the RF circuit
24 board.

25
26 SUMMARY OF THE INVENTION

27
28 These and other objects and advantages are achieved
29 by the present invention by providing a single multi-
30 layer carrier module carrying the power amplifier and
31 the power amplifier controller.

32
33 In a first embodiment of the present invention the
34 power amplifier and the power amplifier controller are
35 placed upon a ceramic carrier module along with
36 necessary connection circuitry. The carrier module is

3

1 Representative functional elements which are
2 currently anticipated to be included within the next
3 generation of wireless communication networks include
4 telephony, videotelephony, and high-speed data
5 transmission. These services have varying and
6 distinguishable needs, transmission characteristics and
7 other requirements which affect the size, weight and
8 cost of cellular technology, and specifically the mobile
9 cellular phone unit.

10

11 Figure 1 shows a graphical block diagram depiction
12 of the several major subsystems within a mobile digital
13 cellular telephone 10 used today. These subsystems
14 include a battery pack 11, a set of user interfaces 12
15 (including a microphone, a speaker, a keyboard and a
16 display), a set of digital control and/or analog device
17 drivers 13 for the user interfaces 12, digital
18 processing and control systems 14, a radio subsystem 15
19 , and an antenna 16. As shown within figure 1, each of
20 the subsystems within the digital cellular phone 10 are
21 interrelated and provide power and control to each
22 other.

23

24 The battery pack 11 initially provides power to
25 both the digital control and analog drivers 13 and the
26 digital processing and control systems 14. The analog
27 drivers and control system 13 controls the user
28 interfaces 12, as well as the radio subsystem 15
29 including separate components such as a power amplifier,
30 a power amplifier controller and a voltage controlled
31 oscillator.

32

33 The power amplifier system within the radio
34 subsystem 15 provides output power for transmission.
35 The radio subsystem 15 further includes a variety of
36 passive and active RF components for transmission and

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1 reception, as well as the power amplifier for
2 transmission through the antenna 16. These radio
3 subsystem components are all provided on an RF board.
4

5 A common power amplifier used in this environment
6 is an integrated circuit chip that is used within GSM
7 digital cellular systems. This is the RI 21005 RF power
8 amplifier available from Rockwell Semiconductor Systems,
9 Newbury Park, California. The RI 21005 RF power
10 amplifier is a compact 20 pin Thin Shrink Small Outline
11 Package (TSSOP) surface mount GSM power amplifier
12 operating within the 880 - 915 MHz cellular band with
13 pulsed output power up to 4 W. The output match is
14 realized outside of the power amplifier.
15

16 A common power amplifier controller is an
17 integrated circuit chip that is used within GSM digital
18 cellular systems. This is the RF122 RF power amplifier
19 controller available from Rockwell Semiconductor
20 Systems, Newport Beach, California. The RF122 RF power
21 amplifier controller is an integrated, monolithic device
22 used to control the transmitted power of MOSFET and
23 MESFET power amplifiers. A graphical block diagram of
24 the RF122 is shown in figure 2.
25

26 As shown in figure 2, the RF122 power amplifier
27 controller consist of two sections: an RF detector and a
28 gain controller. The RF122, in combination with a power
29 amplifier, forms a power amplifier control loop where
30 the power amplifier output power is controlled by a
31 single analog control voltage that is input to the
32 RF122. The RF122 consists of a logarithmic RF detector,
33 an integrating error amplifier, a gain shaper, and D.C.
34 bias circuitry. The RF122 device is also packaged
35 within a 20 pin Thin Shrink Small Outline Package
36 (TSSOP).

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: 7

1 then connected to the RF board.

2

3 In the first embodiment of the present invention,
4 the power amplifier module sits upon an RF board within
5 a GSM digital cellular telephone, the module includes
6 (1) a power amplifier, which is a heterojunction bipolar
7 transistor, (2) a power amplifier controller, which
8 further includes an RF detector and a gain controller,
9 (3) an RF coupler attached to the module, the coupler
10 being electrically attached to an output of the power
11 amplifier and feeding a signal to the input of the power
12 amplifier controller, (4) few passive components to
13 provide input and output matching for the power
14 amplifier and the necessary supporting circuitry for the
15 control loop, and 5) a module substrate. The power
16 amplifier, the power amplifier controller, and the
17 coupler are attached to the module substrate. The
18 coupler is a directional coupler and separating a
19 forward power from a reflected power to maintain a
20 constant output power. The module substrate includes
21 multiple layers, the multiple layers allowing a lattice
22 of connection circuitry to be formed to allow the power
23 amplifier and the power amplifier controller to
24 communicate with each other.

25

26 In a second preferred embodiment of the present
27 invention the power amplifier, the power amplifier
28 controller and a voltage controlled oscillator are
29 placed upon a ceramic or laminate carrier module along
30 with necessary connection circuitry. The carrier module
31 is then connected to the RF board. The second preferred
32 embodiment is constructed similarly to the first
33 preferred embodiment, with the exception that the
34 voltage controlled oscillator is attached to the top
35 surface of the module substrate. The voltage controlled
36 oscillator is attached to the electrical input of the

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1 power amplifier to provide input drive.

2

3 BRIEF DESCRIPTION OF THE DRAWINGS

4

5 The features, organization, advantages and objects
6 of this invention will be fully understood from the
7 following detailed description and the accompanying
8 drawings. The drawings contained herein are not
9 considered to be accurate depictions of the embodiments
10 of the invention, but are provided for illustrative
11 purposes only and are to be interpreted in conjunction
12 with the attached specification.

13

14 Figure 1 shows a graphical block diagram depiction
15 of the several major subsystems within a mobile digital
16 cellular telephone.

17

18 Figure 2 shows a graphical block diagram of a
19 common power amplifier controller known in the art.

20

21 Figure 3 shows a graphical block diagram depiction
22 of a first preferred embodiment of the present
23 invention.

24

25 Figure 4 shows a more detailed graphical block
26 diagram depiction of the first preferred embodiment of
27 the present invention shown in Figure 3.

28

29 Figure 5 shows a graphical illustration of the
30 carrier module of the preferred embodiment of the
31 present invention.

32

33 Figure 6 shows a graphical block diagram depiction
34 of a second preferred embodiment of the present
35 invention.

DETAILED DESCRIPTION OF THE INVENTION

The following description is provided to enable any person skilled in the art to make and use the invention, and sets forth the best modes presently contemplated by the inventor for carrying out this invention. Various modifications, however, will remain readily apparent to those skilled in these arts, since the generic principals of the present invention have been defined herein.

The first preferred embodiment of the present invention is a multiple layer module power amplifier circuit chip made for GSM digital cellular telephones. The multiple layer module of the first preferred embodiment contains a heterojunction bipolar transistor power amplifier and a power amplifier controller which meet the GSM specification.

A block diagram depiction of the first preferred embodiment of the present invention is illustrated in figure 3, and includes a power amplifier 21, a power amplifier controller 22 and a coupler 23. As shown figure 3, the power amplifier receives the digital RF input 24, and outputs a signal through the coupler 23. The power amplifier controller 22 accepts its input 25 from the coupler 23 in order to create a feed back loop input 26 to the power amplifier 21.

A more detailed block diagram of the first preferred embodiment of the present invention is shown in figure 4. As shown in figure 4, the power amplifier controller of the preferred embodiment consists of two sections: an RF detector and a gain controller (integrator). The power amplifier controller and the

10

1 power amplifier form a power amplifier control loop
2 where the power amplifier output power is controlled by
3 a single analog control voltage.
4

5 In the event of a poor voltage standing wave ratio,
6 the preferred embodiment to the present invention
7 includes a built-in directional coupler which separates
8 the forward power from the reflected power in order to
9 maintain a constant output power. In the preferred
10 embodiment of the present invention the power amplifier
11 is designed with a bipolar gallium arsenide process that
12 allows single supply operation while maintaining high
13 efficiency and excellent dynamic range.
14

15 A graphical illustration of the carrier module of
16 the preferred embodiment of the present invention is
17 depicted in figure 5. As the shown in figure 5 , the
18 carrier module 30, has multiple layers 31, which allows
19 circuitry to be inlaid to enable the various power
20 amplifier components to electrically communicate and
21 interact with one another.
22

23 As shown in figure 5, in the preferred embodiments
24 of the present invention, the power amplifier 32, the
25 power amplifier controller 33 and a voltage control
26 oscillator 34 all sit upon the top layer of the multiple
27 layer carrier module 30. A coupler is inlaid below the
28 surface of the carrier module on other lower layers 31.
29 Other connection circuitry is also embedded within the
30 multiple layers of the carrier module 30. Common
31 insulation or packaging is provided in order to protect
32 the power amplifier components attached to the top
33 surface of the carrier module substrate.
34

35 The carrier module of the preferred embodiment of
36 the present invention is ceramic or laminate. In the

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1 preferred embodiment of ¹¹the present invention the
2 substrate is a B.T. laminate available from Details,
3 Inc., Anaheim, California.

4
5 A second preferred embodiment of the present
6 invention is depicted in the block diagram illustration
7 shown in figure 6. As shown in figure 6, the carrier
8 module 40 includes the same components as the carrier
9 module depicted in figure 3 along with a voltage
10 controlled oscillator 41. The second preferred
11 embodiment illustrated in figure 6 operates in the same
12 manner as the power amplifier system illustrated in
13 figure 3 with the addition that the voltage controlled
14 oscillator 41 is integrated on the carrier module to
15 drive the power amplifier.

16

17 Those skilled in the art will appreciate that
18 various adaptations and modifications of the just
19 described preferred embodiment can be used and
20 configured without departing from the scope and spirit
21 of the invention. Therefore, it is to be understood
22 that, within the scope of the appended claims, the
23 invention may be practiced other than as specifically
24 described herein.

; 12
CLAIMS

1

2

3 What is Claimed Is:

4

1 A power amplifier module upon an RF board

2 within a digital cellular telephone, the module

3 comprising:

4

5 a power amplifier;

6

7 a power amplifier controller; and

8

9 a module substrate, the power amplifier and

10 the power amplifier controller attached

11 to the module substrate, the substrate

12 being attachable to the RF board.

1 2. The module of Claim 1 wherein the power
2 amplifier is a heterojunction bipolar transistor.

1 3. The module of Claim 1 wherein the module
2 meets a GSM specification.

1 4. The module of Claim 1, further comprising
2 an RF coupler attached to the module, the coupler being
3 electrically attached to an output of the power
4 amplifier.

1 5. The module of Claim 4, wherein the coupler
2 feeds a signal to the input of the power amplifier
3 controller.

1 6. The module of Claim 5, wherein the coupler
2 is a directional coupler which separates a forward power
3 from a reflected power to maintain a constant output
4 power.

1 7. The module of claim 1, wherein the power
2 amplifier controller further includes an RF detector and
3 a gain controller.

1 8. The module of Claim 1, wherein the power
2 amplifier receives a single analog control voltage

3 signal and the power amplifier and the power amplifier.
4 controller form a power amplifier control loop.

1 9. The module of Claim 1, wherein the power
2 amplifier is designed with a bipolar gallium arsenide
3 process.

1 10. The module of Claim 1, wherein the module
2 substrate further comprises multiple layers, the
3 multiple layers providing a lattice of connection
4 circuitry to allow the power amplifier and the power
5 amplifier controller to communicate with each other.

1 11. The module of Claim 10, wherein the power
2 amplifier, the power amplifier controller and a voltage
3 controlled oscillator sit upon a top surface of the
4 multiple layer module substrate.

: 15

1 12. The module of Claim 10, wherein a coupler
2 is inlaid upon the multiple layer module substrate, the
3 coupler being inlaid upon layers of the substrate below
4 a top layer.

1 13. The module of Claim 10, wherein the
2 substrate is BT laminate.

1 14. The module of Claim 1, further comprising
2 a voltage controlled oscillator attached to the module
3 substrate, the voltage controlled oscillator being
4 connected at an input to the power amplifier.

1 15. A power amplifier module upon an RF board
2 within a digital cellular telephone, the module
3 comprising:

4
5 a power amplifier, the power amplifier being a
6 heterojunction bipolar transistor;

7
8 a power amplifier controller, the power
9 amplifier controller further including an
10 RF detector and a gain controller;

11
12 an RF coupler attached to the module, the
13 coupler being electrically attached to an
14 output of the power amplifier, the

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16

15 coupler feeding a signal to the input of
16 the power amplifier controller, the
17 coupler being a directional coupler and
18 separating a forward power from a
19 reflected power to maintain a constant
20 output power;

21
22 a module substrate, the power amplifier, the
23 power amplifier controller, and the
24 coupler attached to the module substrate,
25 the module substrate further comprises
26 multiple layers, the multiple layers
27 providing a lattice of connection
28 circuitry to allow the power amplifier
29 and the power amplifier controller to
30 communicate with each other, the module
31 substrate being attachable to the RF
32 board.

1 16. The module of Claim 15, wherein the
2 module meets a GSM specification.

1 17. The module of Claim 15, wherein the power
2 amplifier receives a single analog control voltage
3 signal and the power amplifier and the power amplifier
4 controller form a power amplifier control loop.

1 18. The module of Claim 15, wherein the power

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2 amplifier, the power amplifier controller and a voltage
3 controlled oscillator sit upon a top surface of the
4 multiple layer module substrate.

1 19. The module of Claim 15, wherein the
2 coupler is inlaid upon the multiple layer module
3 substrate, the coupler being inlaid upon layers of the
4 substrate below a top layer.

1 20. The module of Claim 15, further
2 comprising a voltage controlled oscillator, the voltage
3 controlled oscillator being electrically connected at an
4 input to the power amplifier, the voltage controlled
5 oscillator being attached to the top surface of the
6 module substrate.

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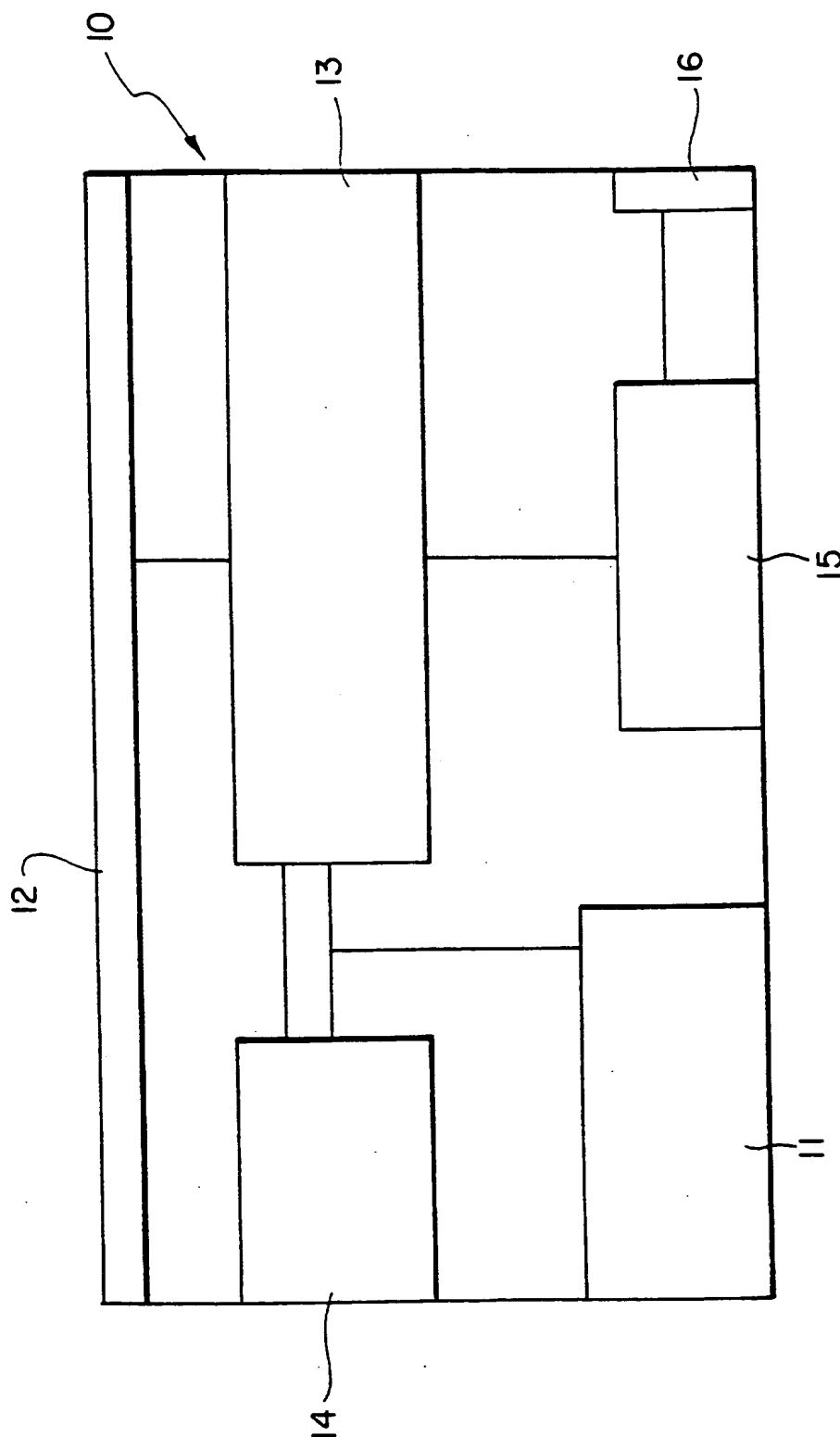


FIG. 1

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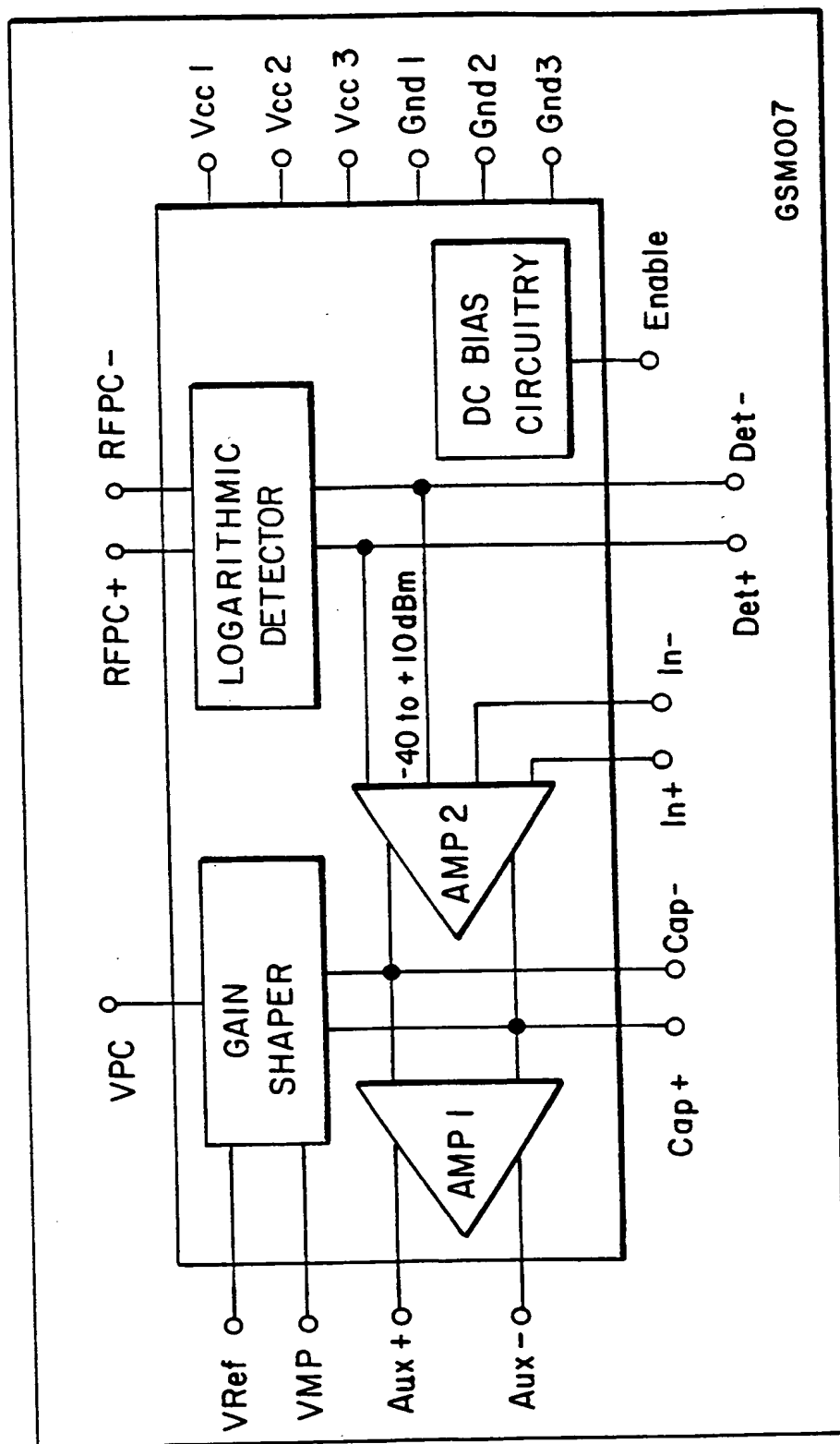
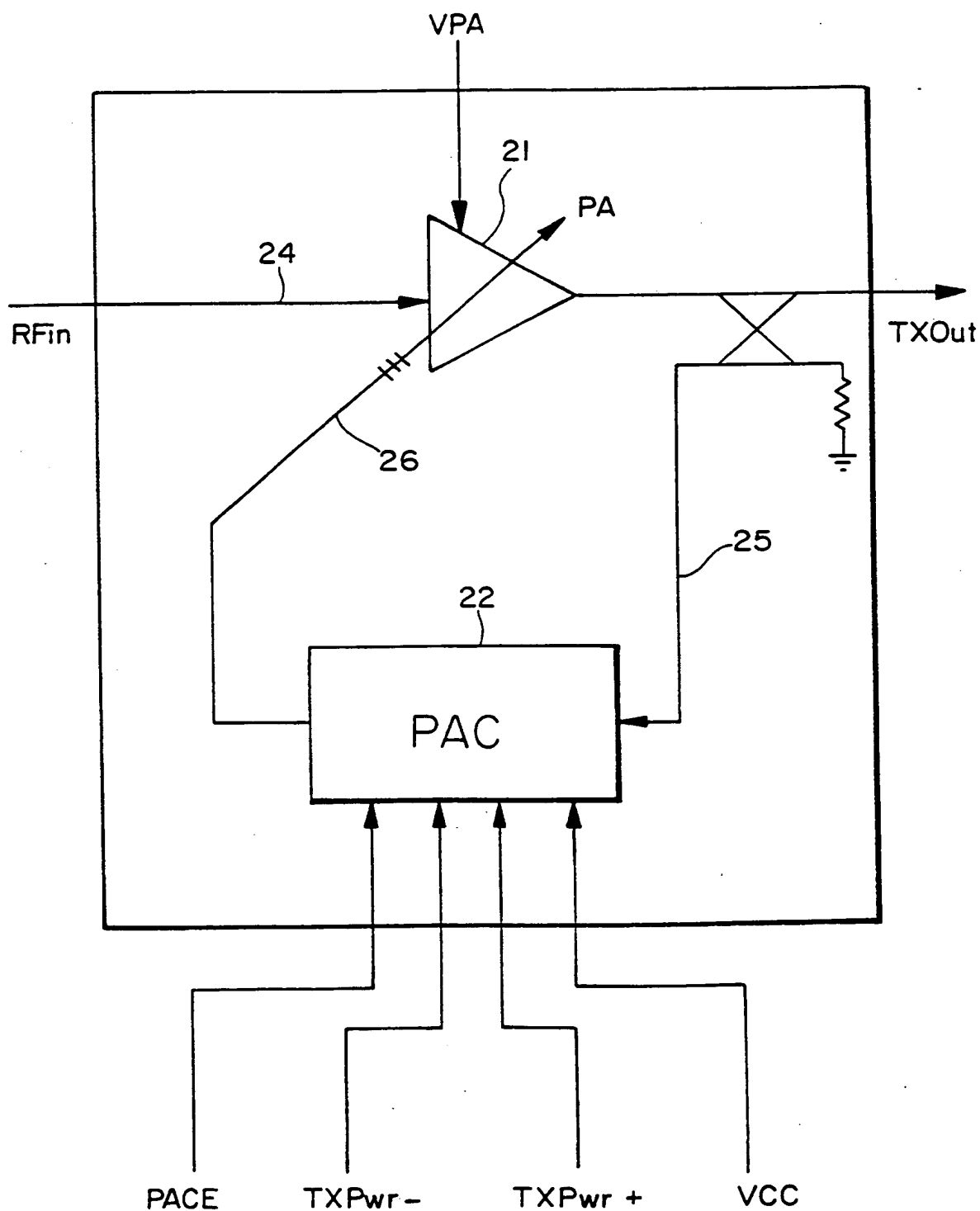


FIG. 2

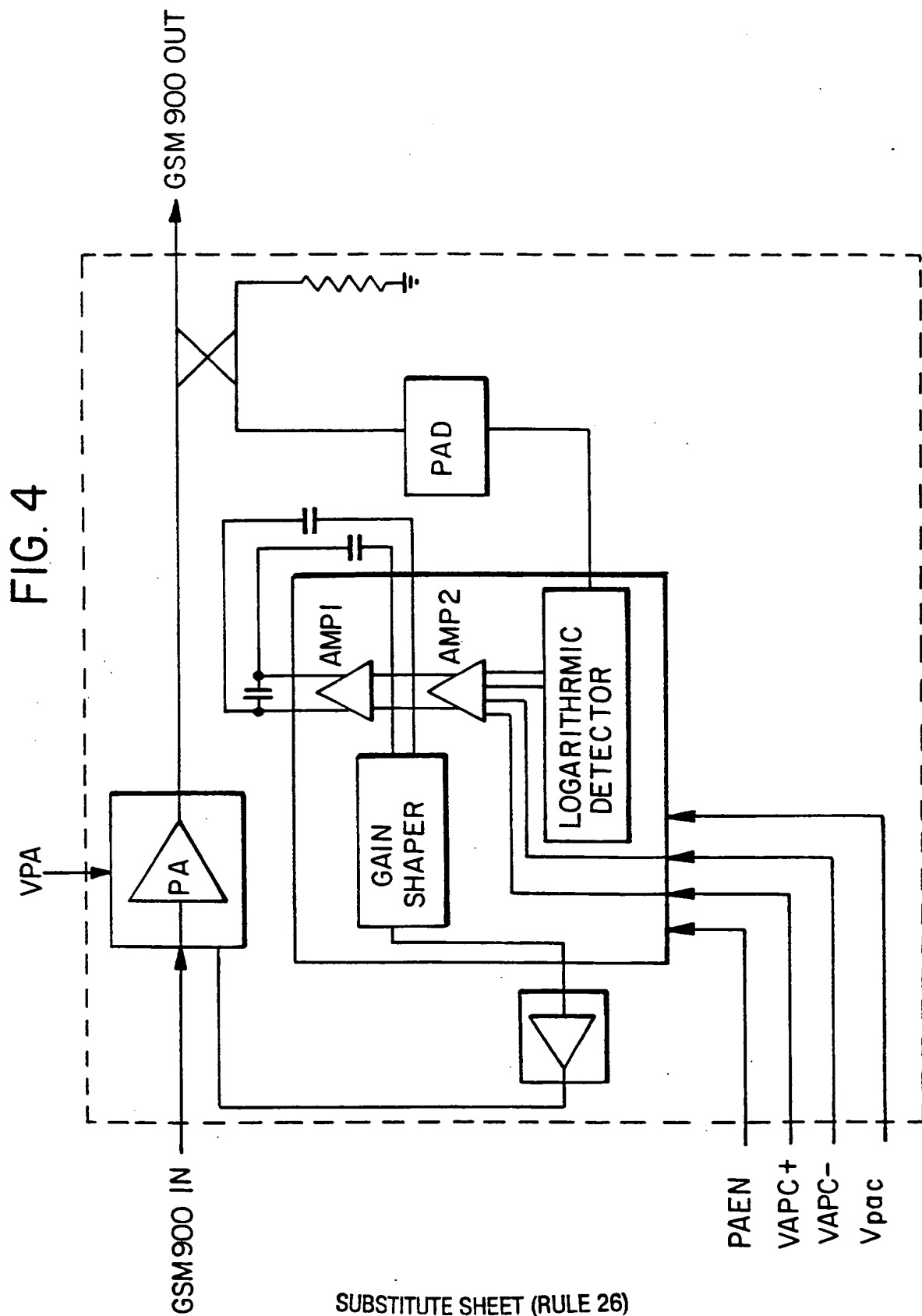
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FIG. 3



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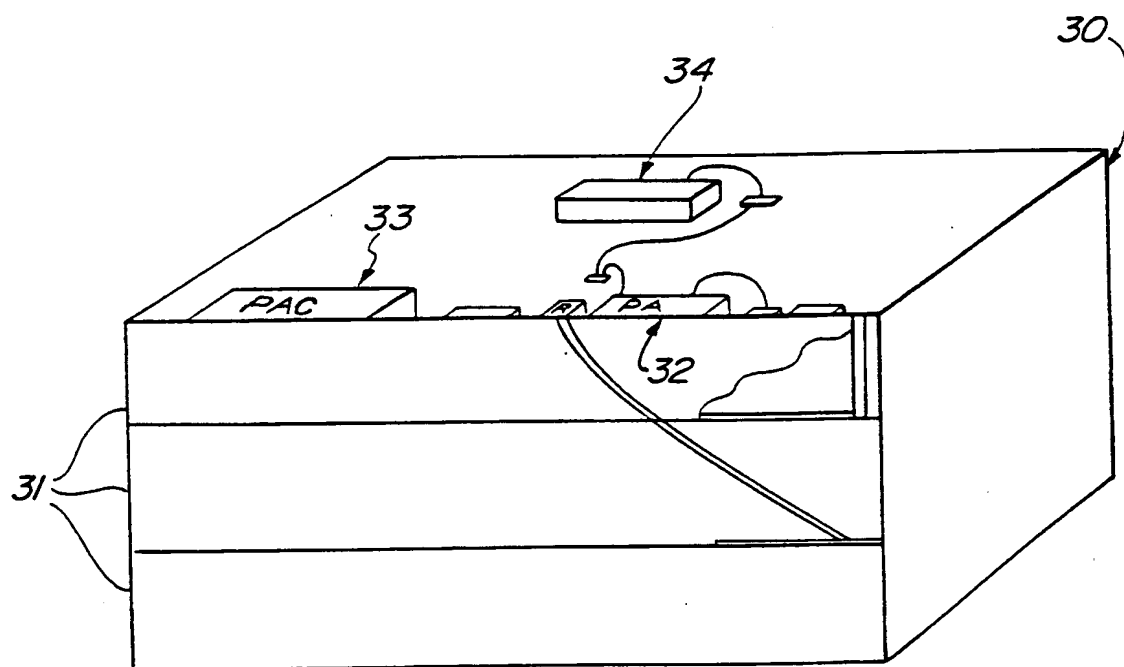


FIG. 5

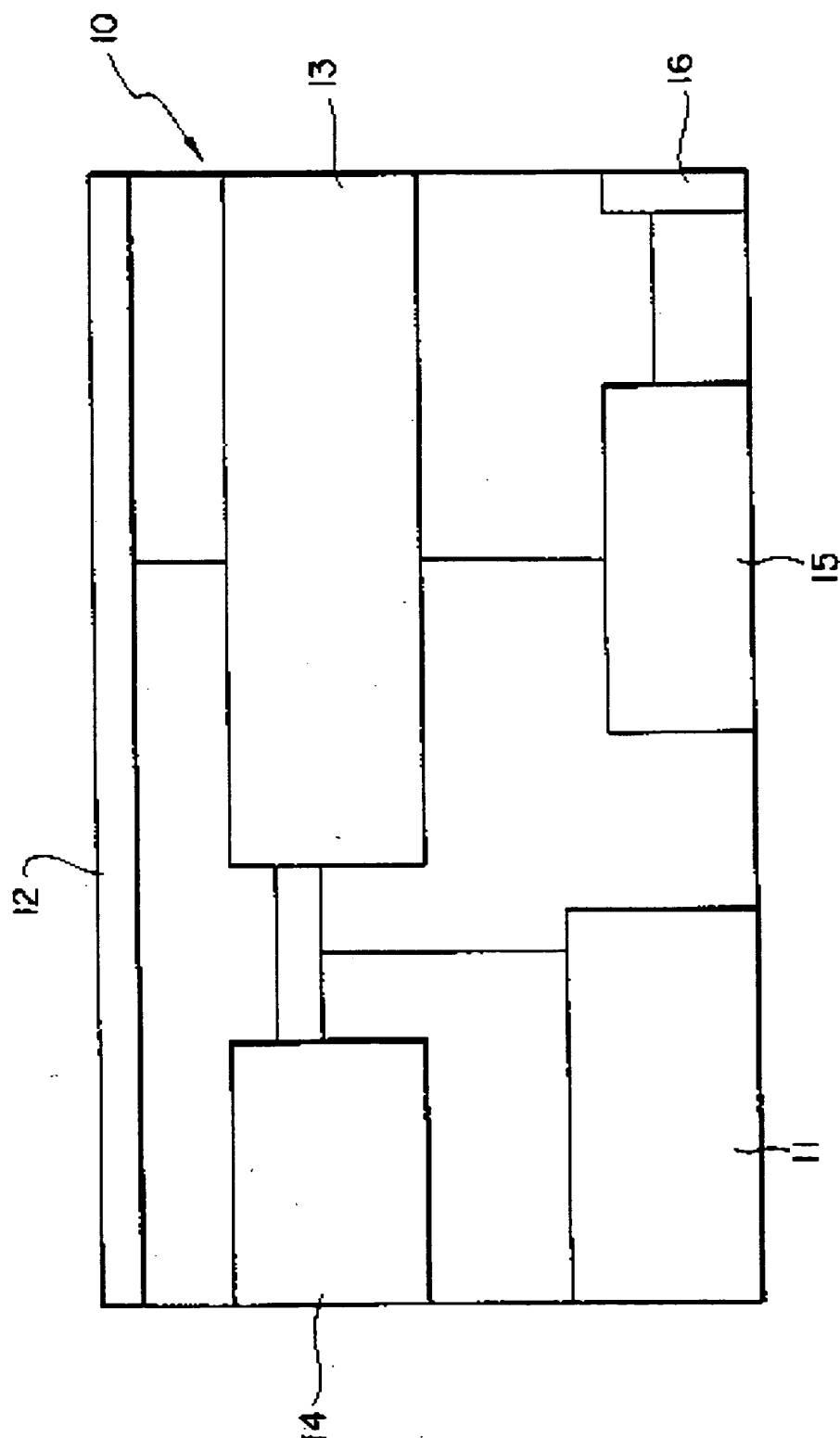


FIG. 1

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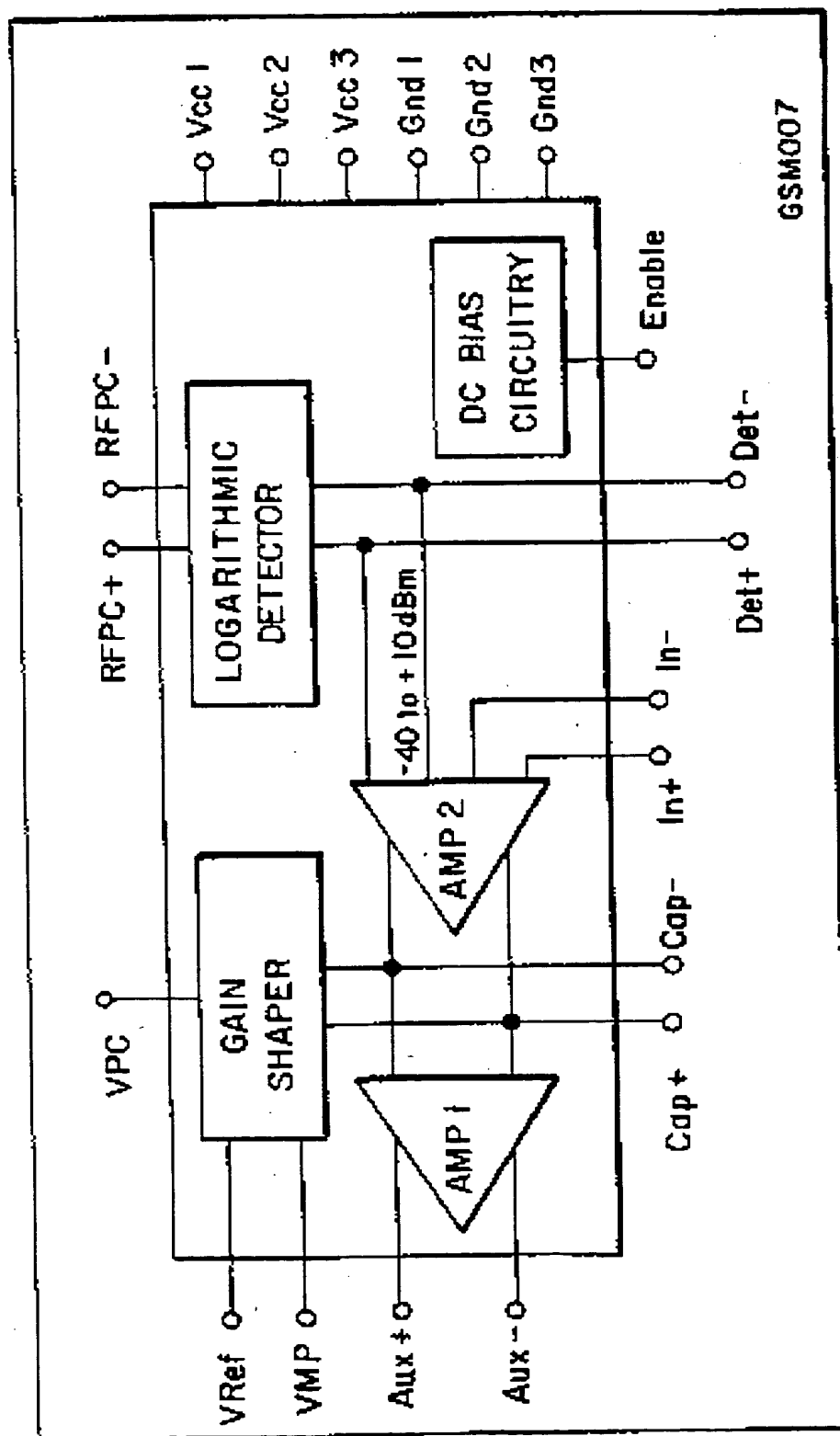
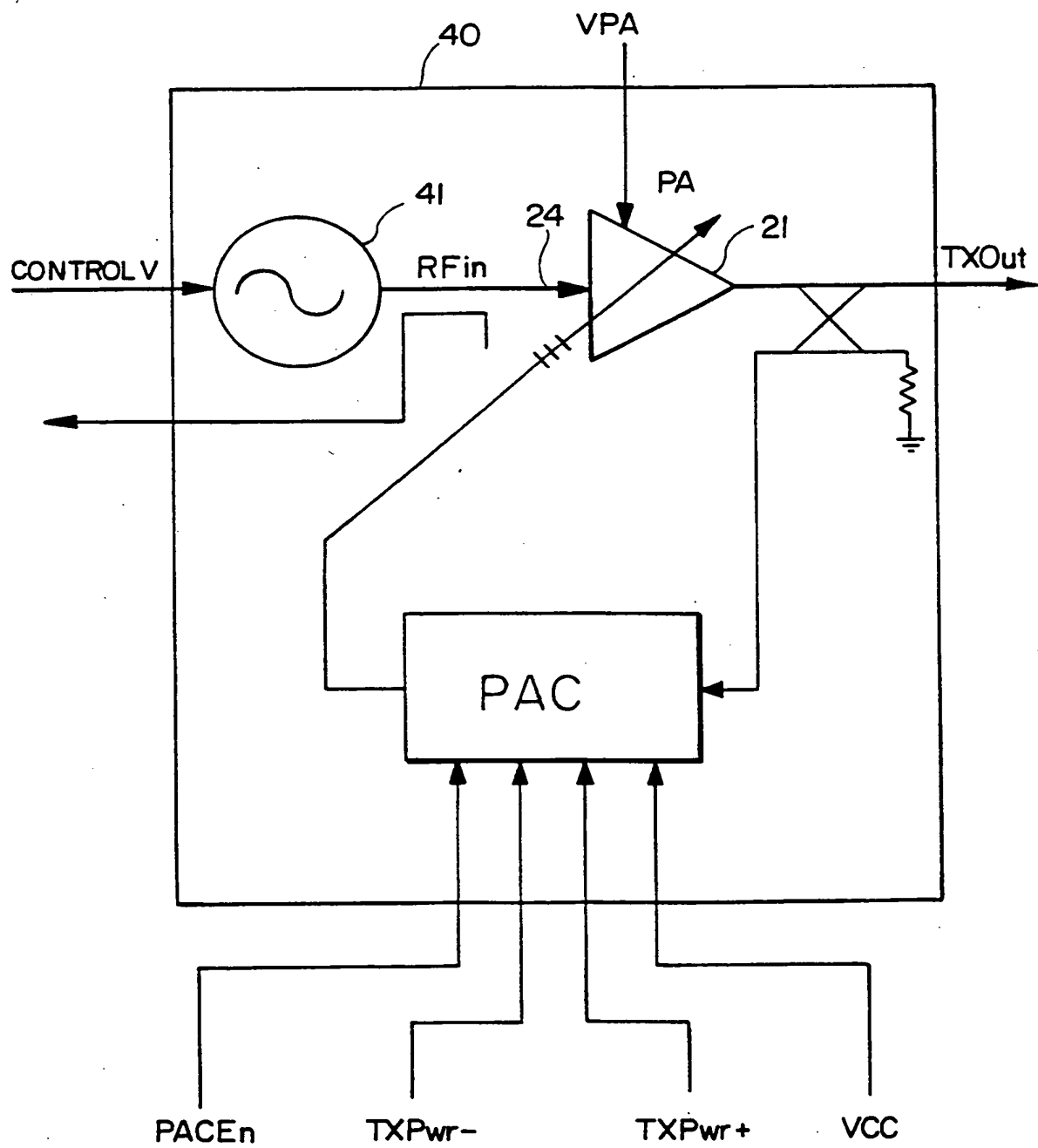


FIG. 2

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FIG. 6

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/20574

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : H03G 3/30

US CL : 330/279

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 330/279, 65, 66, 286, 307, 375/345, 455/126, 128

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,142,239 A (BRAYTON ET AL.) 25 August 1992 (25/08/92), see Fig. 2 and col. 4, lines 64-66.	1-20
X	US 5,450,046 A (KOSUGI ET AL.) 12 September 1995 (12/09/95), see Fig. 6 and col. 6, lines 50-62.	1-20

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:	* T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search

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Date of mailing of the international search report

12 JAN 1999

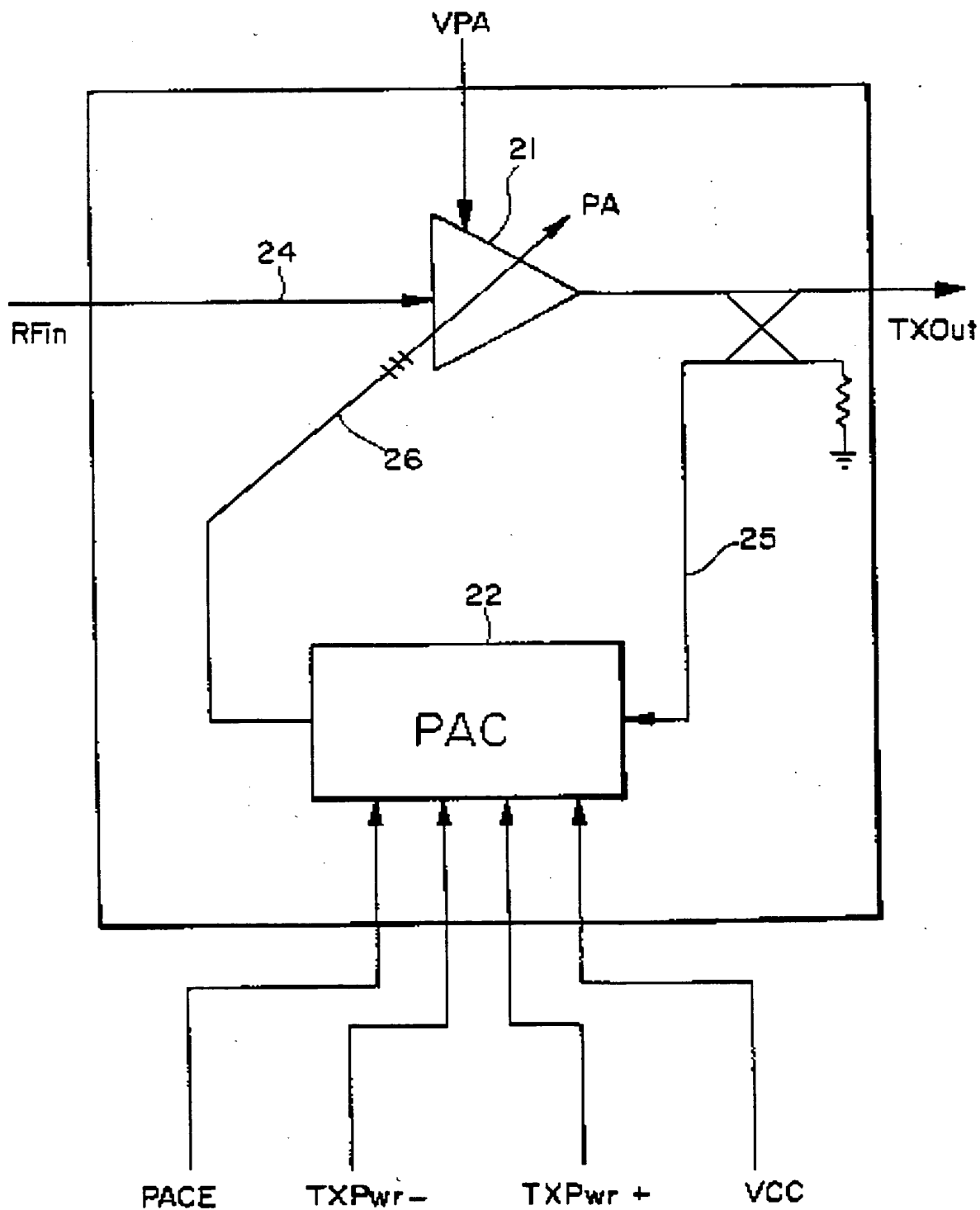
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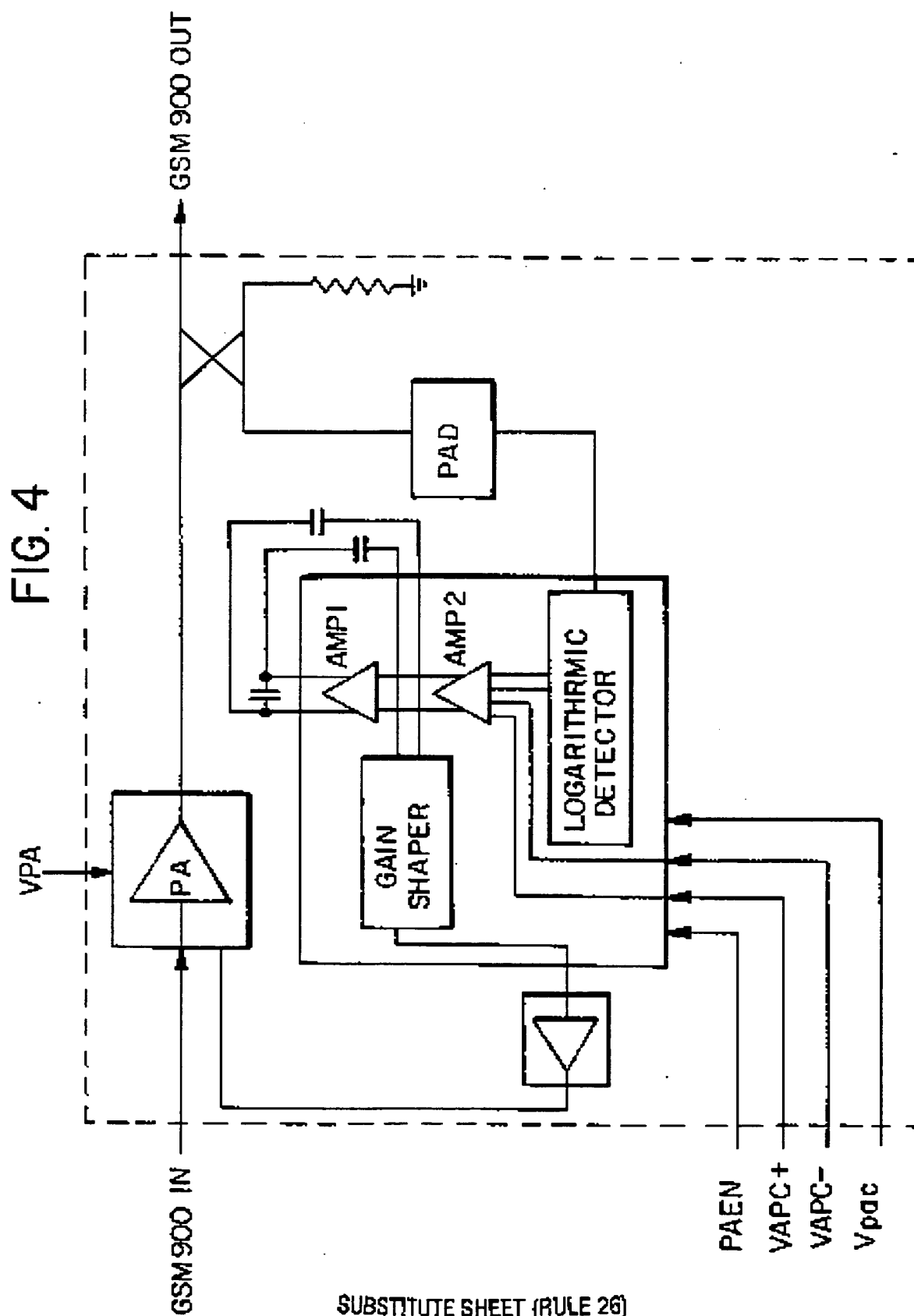
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FIG. 3



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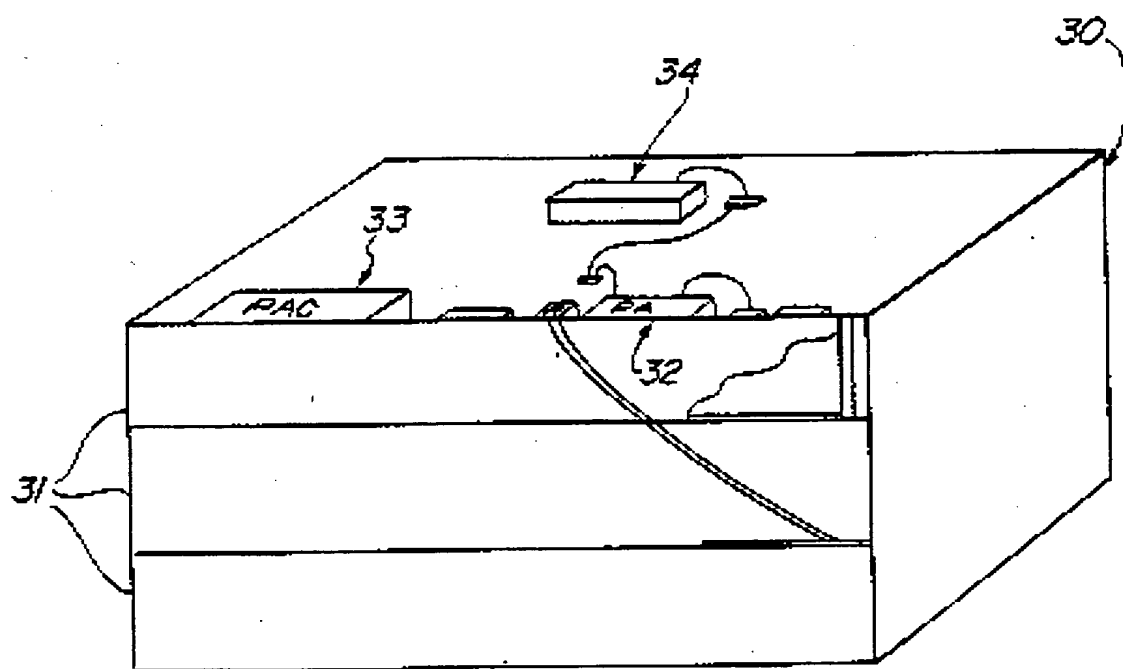


FIG. 5

